CHAPTER 3

Safety and Quality Assessment

LEARNING OUTCOMES

Upon completing this chapter, the reader will be able to:

3-1 Identify the components of the nephron, kidney, and excretory system.

3-2 Trace the flow of blood through the nephron and state the physiologic functions that blood through the nephron and occur.

3-3 Describe the process of glomerular blood through the nephron and ultrafiltration.

3-4 Trace the flow of blood through the nephron and state the physiologic functions that occur.

3-5 Describe the process of glomerular ultrafiltration.

3-6 Trace the flow of blood clinical significance of the glomerular filtration rate tests through the nephron and state the physiologic functions that occur.

3-7 Describe the process of clinical significance of the glomerular filtration rate tests glomerular ultrafiltration.

3-8 Describe the process of process of glomerular blood through the nephron and ultrafiltration glomerular ultrafiltration.

3-9 Given hypothetic laboratory data, process of glomerular ultrafiltration calculate a creatinine clearance and determine whether the result is normal.

3-10 Discuss the clinical significance of the glomerular filtration rate tests.

3-11 Describe and contrast the MDRD, Cystatin C, and beta 2 microglobulin tests for performing estimated glomerular filtration rates (**eGFR**).

3-12 Trace the flow of blood through the nephron and state the physiologic functions that occur.

3-13 Describe the process of glomerular ultrafiltration.

3-14 Trace the flow of blood clinical significance of the glomerular filtration rate tests through the nephron and state the physiologic functions that occur.

3-15 Describe the process of clinical significance of the glomerular filtration rate tests glomerular ultrafiltration.

3-16 Describe the process of process of glomerular blood through the nephron and ultrafiltration glomerular ultrafiltration.

3-17 Trace the flow of blood clinical significance of the glomerular filtration rate tests through the nephron and state the physiologic functions that occur.

3-18 Describe the process of clinical significance of the glomerular filtration rate tests glomerular.

KEY TERMS

active transport
beta2 microglobulin
Cystatin C
distal convoluted tubule
active transport
beta2 microglobulin

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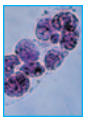
Safety procedures and quality assessment are essential priorities for clinical laboratory personnel. Safety policies and procedures are continually being developed to protect healthcare workers and to maintain a safe environment for both employees and patients, and to prevent the spread of disease. Quality assessment (QA) includes procedures for the monitoring and evaluation of patient care services and the resolving of identified problems. Clinical laboratory personnel must understand their role in both the safety and quality assessment of laboratory testing and recognize the effect that both have on patient diagnosis, treatment, and well-being.

SAFETY

Physiology



The large intestine is capable of absorbing approximately 3000 mL of water. When the amount of water reaching the large intestine exceeds this amount, it is excreted with the solid fecal material, producing **diarrhea**. **Constipation**, on the other hand, provides time for additional water to be reabsorbed from the fecal material, producing small, hard **stools**.

Diarrhea

Diarrhea is defined as an increase in daily stool weight above 200 g, increased liquidity of stools, and frequency of more than three times per day. Diarrhea classification can be based on four factors: illness duration, mechanism, severity, and stool characteristics. Diarrhea lasting less than 4 weeks is defined as acute.

Secretory Diarrhea

Secretory diarrhea is caused by increased secretion of water. Bacterial, viral, and protozoan infections produce increased secretion of water and electrolytes, which override the reabsorptive ability of the large intestine, leading to secretory diarrhea. Enterotoxin-producing organisms such as *Escherichia coli, Clostridium, Vibrio cholerae, Salmonella, Shigella, Staphylococcus, Campylobacter,* protozoa, and parasites such as *Cryptosporidium* can stimulate these secretions.

Creatinine Clearance

Creatinine, a waste product of muscle metabolism (produced enzymatically by creatine phosphokinase from creatine which links with ATP to produce ADP and energy) that is normally found at a relatively constant level in the blood, provides the laboratory with an endogenous procedure for evaluating glomerular function. The use of creatinine has several disadvantages and careful consideration should be given to them. They are as follows:

The original screening tests for occult blood are based on detecting the pseudoperoxidase activity of hemoglobin. This is the same principle as the reagent strip test for urinary blood, but uses a different indicator chromogen. The reaction uses the pseudoperoxidase activity of hemoglobin reacting with hydrogen peroxide to oxidize a colorless compound to a colored compound:

$$\text{Hemoglobin} \xrightarrow{\text{H2O2}} \xrightarrow{\text{Guaiac}} \xrightarrow{\text{O}} \text{Oxidized guaiac} + \text{H2O}$$

(Blue color)

The fat content is reported as grams of fat or the coefficient of fat retention per 24 hours. Normal values based on a 100 g/d intake are 1 to 6 g/d or a coefficient of fat retention of at least 95%. The coefficient of fat retention is calculated as follows:

$$\frac{(\text{dietary fat} - \text{fecal fat}) \times 100}{(\text{dietary fat})}$$

Once the infectious agent has left the reservoir it must have a way to reach a susceptible host. Means of transmission include:

- **Direct contact:** the unprotected host touches the patient, specimen, or a contaminated object (reservoir)
- **Airborne:** inhalation of dried aerosol particles circulating on air currents or attached to dust particles
- **Droplet:** the host inhales material from the reservoir (e.g. ***aerosol*** droplets from a patient or an uncapped centrifuge tube, or when specimens are aliquoted or spilled)
- **Vehicle:** ingestion of a contaminated substance (e.g., food, water, specimen)
- **Vector:** from an animal or insect bite

Standard Precautions are as follows:

1. **Hand Hygiene:** Hand hygiene includes both hand washing and the use of alcohol-based antiseptic cleansers. Sanitize hands after touching blood, body fluids, secretions, excretions, and contaminated items, whether or not gloves are worn. Sanitize hands immediately after gloves are removed, between patient contacts, and when otherwise indicated to avoid transfer of microorganisms to other patients or environments. Sanitizing hands may be necessary between tasks and procedures on the same patient to prevent cross-contamination of different body sites.
2. **Gloves:** Wear gloves (clean, nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions, and contaminated items. Put on gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms. Remove gloves promptly after use, before touching noncontaminated items and environmental surfaces, and between patients. Always sanitize your hands immediately after glove removal to avoid transfer of microorganisms to other patients or environments.

3. **Mouth, nose, and eye protection:** Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during procedures and patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. A specially fitted respirator (N95) must be used during patient care activities related to suspected mycobacterium exposure.

OSHA also requires all facilities that use hazardous chemicals to have a written ***chemical hygiene plan*** (CHP) available to employees.[13] The purpose of the plan is to detail the following:

Fire/Explosive Hazards

The Joint Commission (JC) requires that all health-care institutions post evacuation routes and detailed plans to follow in the event of a fire. Laboratory personnel should be familiar with these procedures. When a fire is discovered, all employees are expected to take the actions in the acronym RACE:

Rescue—rescue anyone in immediate danger

Alarm—activate the institutional fire alarm system

Contain—close all doors to potentially affected areas

Extinguish/Evacuate—attempt to extinguish the fire, if possible or evacuate, closing the door

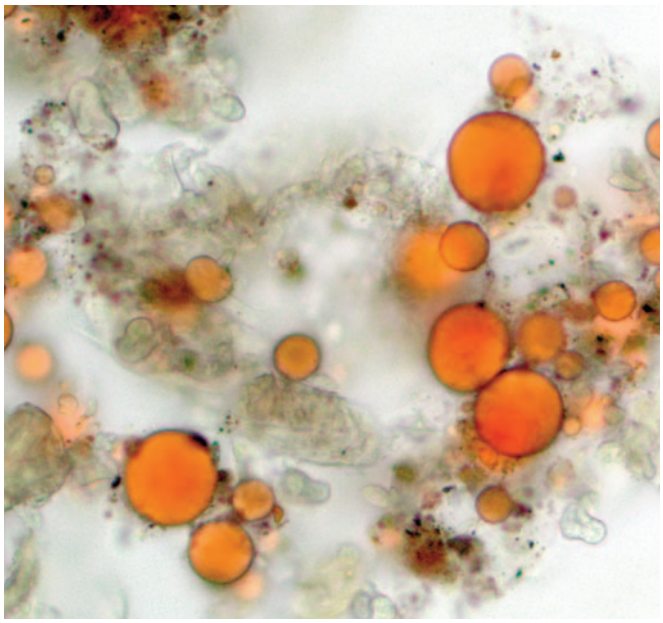


Figure 14–1 Fluid regulation in the gastrointestinal tract. (Adapted from the Department of Pathology, Methodist Hospital, Omaha, Nebr., with permission.)

The fat content is reported as grams of fat or the coefficient of fat retention per 24 hours. Normal values based on a 100 g/d intake are 1 to 6 g/d or a coefficient of fat of at least 95%. The coefficient of fat retention is calculated as follows:

Table 14–1 Common Fecal Tests for Diarrhea

Secretory	Osmotic
Stool cultures	Microscopic fecal fats
Ova and parasite examinations	Muscle fiber detection
Rotavirus immunoassay	Qualitative fecal fats
Fecal leukocytes	Trypsin screening
	Microscopic fecal fats
	Muscle fiber detection
	Quantitative fecal fats
	Clinitest
	D-Xylose tolerance test
	Lactose tolerance test
	Fecal electrolytes
	Stool pH
	Fecal osmolality

From Schweitzer, SC, Schumann, JL, and Schumann, GB: Quality assurance guidelines for the urinalysis laboratory. Journal of Medical Technology 3(11): 568, 1986, with permission.

SUMMARY 3-3 Structure Function

Seminiferous Tubules

Seminiferous tubules of testes Spermatogenesis EpididymisSperm maturation Ductus deferens Propel sperm to ejaculatory ducts Seminal vesicles Provide

Nutrients for sperm and fluid Prostate gland Provide enzymes and proteins for coagulation and liquefaction Bulbourethral glands Add alkaline mucus to neutralize prostatic acid and vaginal acidity

References

1. Singh, A, Gull, H, and Singh, R: Clinical significance of rapid (accelerated) gastric emptying. Clin Nucl Med 28(8)
2. Ukleja, A: Dumping syndrome: Pathophysiology and treatment. Nutr Clin Pract 20(5):517-525, 2005.
3. Koepke, JA: Tips from the clinical experts. MLO, p. 15, 1995.
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5. Novak, R, et al: How useful are fecal neutrophil determinations? Lab Med 26(11):433, 1995.

Additional Information Sources

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Iris Diagnostics, Chatsworth, CA: www.irisdiagnostics.com

Roche Diagnostics, Indianapolis, IN: HYPERLINK "http://www.roche.com" www.roche.com/products
Siemens Healthcare Diagnostics Inc. Deerfield, IL: http://www.usa.siemens.com/diagnostics
Sysmex America, Inc. Mundelein, IL: www.sysmex.com/usa
"http://www.roche.com" www.roche.com/products
Siemens Healthcare Diagnostics Inc. Deerfield, IL: http://www.usa.siemens.com/diagnostics

Log on to

Study Questions

1. In what part of the digestive tract do pancreatic enzymes and bile salts contribute to digestion?
   A. Large intestine
   B. Liver
   C. Small intestine
   D. Stomach
2. Which of the following tests differentiates a malabsorption cause from a maldigestion cause in steatorrhea?
   A. APT test
   B. D-Xylose test
   C. Lactose tolerance test
   D. Occult blood test
4. Match the following crystals seen in alkaline urine with their description/identifying characteristics:

____ Triple phosphate	1. Yellow granules
____ Amorphous phosphate	2. Thin prisms
____ Calcium phosphate	3. "Coffin lids"
____ Ammonium biurate	4. Dumbbell shape
____ Calcium carbonate	5. White precipitate

5. Thorny apple
6. Which of the following tests differentiates a malabsorption cause from a maldigestion cause in steatorrhea?
7. In what part of the digestive tract do pancreatic enzymes and bile salts contribute to digestion?

Case Studies and Clinical Situations

1. Microscopic screening of a stool from a patient exhibiting prolonged diarrhea shows increased fecal neutrophils and normal qualitative fecal fats and meat fibers.
   a. What type of diarrhea do these results suggest?
   b. Name an additional test that could provide more diagnostic information.
   c. Name one probable result for this test and one improbable result.
   d. If the test for fecal neutrophils was negative and the fecal fat concentration increased, what type of diarrhea is suggested?
2. An 85-year-old woman with diabetes and a broken hip has been confined to bed for the past 3 months. Results of an ancillary blood glucose test are 250 mg/dL, and her physician orders additional blood tests and a routine urinalysis. The urinalysis report is as follows:

COLOR: Pale yellow	KETONES: Negative
CLARITY: Hazy	BLOOD: Moderate
SP. GRAVITY: 1.020	BILIRUBIN: Negative
pH: 5.5	UROBILINOGEN: Normal
PROTEIN: Trace	NITRITE: Negative

Microscopic:

20 to 25 WBCs/hpf	Many yeast cells and hyphae

   a. Why are yeast infections common in patients with diabetes mellitus?
   b. With a blood glucose level of 250 mg/dL, should glucose be present in the urine? Why or why not?
   c. Is there a discrepancy between the negative nitrite and the positive leukocyte esterase results? Explain your answer.
   d. What is the major discrepancy between the chemical and microscopic results?
   e. What is the major discrepancy between the chemical and microscopic results?
   f. Considering the patient's history, what is the most probable cause for the discrepancy?
3. A prisoner sentenced to 10 years for selling illegal drugs develops jaundice, lethargy, and hepatomegaly. A test for hepatitis B surface antigen is positive, and the patient is placed in the prison infirmary.
4. Microscopic screening of a stool from a patient exhibiting prolonged diarrheaameat fibers.

HISTORICAL NOTE

Sulfosalicylic Acid Precipitation Test

The urinometer consists of a weighted float attached to a scale that has been calibrated in terms of urine specific gravity. The weighted float displaces a volume of liquid equal to its weight and has been designed to sink to a level of 1.000 in distilled water. The additional mass provided by the dissolved substances in urine causes the float to displace a volume of urine smaller than that of distilled water. The level to which the urinometer sinks, as shown in the figure, represents the specimen's mass or specific gravity.

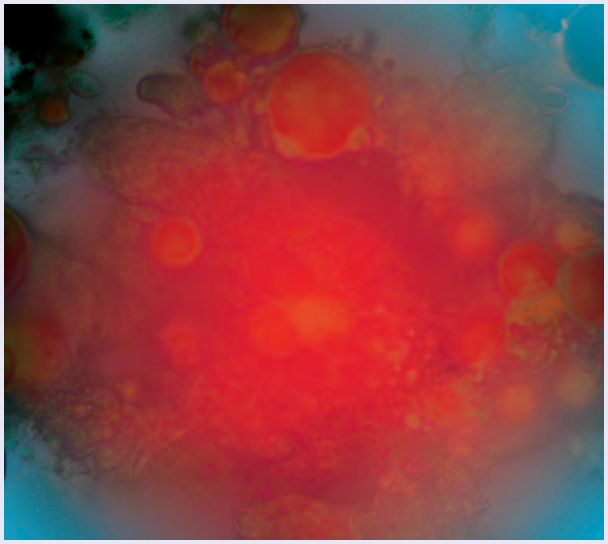

Figure 4–1 Fluid regulation in the gastrointestinal tract. (Adapted from the Department of Pathology, Methodist Hospital, Omaha, Nebr., with permission.)

Urinometry is less accurate than the other methods currently available and is not recommended by the Clinical and Laboratory Standards Institute (CLSI).

The sulfosalicylic acid (SSA) test is a cold precipitation test that reacts equally with all forms of protein. Various concentrations and amounts of SSA can be used to precipitate protein, and methods vary greatly among laboratories. All precipitation tests must be performed on centrifuged specimens to remove any extraneous contamination. Based on the protocol of the laboratory, an SSA test may be performed in certain situations.[5]

Watson-Schwartz Differentiation Test

The classic test for differentiating between urobilinogen, porphobilinogen, and Ehrlich-reactive compounds is the Watson-Schwartz test. The test is performed as follows:

Tube 1	Tube 2
2 mL urine	2 mL urine
2 mL chloroform	2 mL butanol
4 mL sodium acetate	4 mL sodium acetate

The addition of chloroform to Tube 1 results in the extraction of urobilinogen into the chloroform (bottom) layer, producing a colorless urine (top) layer, and a red chloroform layer on the bottom. Neither porphobilinogen nor other Ehrlich-reactive compounds are soluble in chloroform. Porphobilinogen is also not soluble in butanol; however, urobilinogen and other Ehrlich-reactive compounds are extracted into butanol. Therefore, the addition of butanol to Tube 2 produces a red (upper) butanol layer if urobilinogen or Ehrlich-reactive compounds are present and a colorless butanol layer if porphobilinogen is present. As shown in Figure 8-5.

PROCEDURE 3-1

Watson-Schwartz Test

Label 2 tubes #1 and #2

Tube 1	Tube 2
2 mL urine	2 mL urine
2 mL chloroform	2 mL butanol
4 mL sodium acetate	4 mL sodium acetate

Vigorously shake both tubes.

Place in a rack for layers to settle.

Observe both tubes for red color in the layers.

Interpretation:

Tube 1

Upper layer = urine; if colorless = porphobilinogen or Ehrlich-reactive compounds.

Bottom layer = chloroform; if red = urobilinogen.

If both layers are red re-extract the urine layer from tube 1.

Place 2 mL of urine layer from tube 1 and 2 mL chloroform and 4 mL sodium acetate into a new tube. Repeat procedure.

Interpretation: Upper layer – urine colorless

Bottom layer – chloroform—red = excess urobilinogen

Both layers red = porphobilinogen and urobilinogen

Tube 2

Upper layer = butanol; If red = urobilinogen or Ehrlich-reactive compounds

Bottom layer = urine; If colorless = porphobilinogen

HISTORICAL NOTE

Sulfosalicylic Acid Precipitation Test

The urinometer consists of a weighted float attached to a scale that has been calibrated in terms of urine specific gravity. The weighted float displaces a volume of liquid equal to its weight and has been designed to sink to a level of 1.000 in distilled water. The additional mass provided by the dissolved substances in urine causes the float to displace a volume of urine smaller than that of distilled water. The level to which the urinometer sinks, as shown in the figure, represents the specimen's mass or specific gravity.

Urinometry is less accurate than the other methods currently available and is not recommended by the Clinical and Laboratory Standards Institute (**CLSI**).

Chloroform and butanol, and porphobilinogen is soluble in neither. If both urobilinogen and porphobilinogen are present.

The addition of chloroform to Tube 1 results in the extraction of urobilinogen into the chloroform (bottom) layer, producing a colorless urine (top) layer, and a red chloroform layer on the bottom. Neither porphobilinogen nor other Ehrlich-reactive compounds are soluble in chloroform. Porphobilinogen is also not soluble in butanol; however, urobilinogen and other Ehrlich-reactive compounds are extracted into butanol. Therefore, the addition of butanol to Tube 2 produces a red (upper) butanol layer if urobilinogen or Ehrlich-reactive compounds are present and a colorless butanol layer if porphobilinogen is present. As shown in Figure 8-5. The addition of chloroform to Tube 1 results in the extraction of urobilinogen into the chloroform (bottom) layer, producing a colorless urine (top) layer, and a red chloroform layer on the bottom. Neither porphobilinogen nor other Ehrlich-reactive compounds are soluble in chloroform. Porphobilinogen is also not soluble in butanol; however.

The addition of chloroform to Tube 1 results in the extraction of urobilinogen into the chloroform (bottom).

Table **Reporting SSA Turbidity**

Grade	Grade
Stool cultures	Microscopic fecal fats
Ova and parasite examinations	Muscle fiber detection
Rotavirus immunoassay	Qualitative fecal fats
Fecal leukocytes	Trypsin screening

From Schweitzer, SC, Schumann, JL, and Schumann, GB: Quality assurance guidelines for the urinalysis laboratory. Journal of Medical Technology 3(11): 568, 1986, with permission.

TECHNICAL TIP Process specimens for osmolality testing immediately. Specimens that are stored for hours may have a markedly increased osmolality due to the increased degradation of carbohydrates.

EXAMPLE

Calculate the urine volume (V) for a 2-hour specimen measuring 240 mL:

$$2 \text{ hours} \times 60 \text{ minutes} = 120 \text{ minutes}$$
$$240 \text{ mL}/120 \text{ minutes} = 2 \text{ mL/min}$$
$$V = 2 \text{ mL/min}$$

The plasma and urine concentrations are determined by chemical testing. The standard formula used to calculate the milliliters of plasma cleared per minute (C) is:

$$C = \text{EMBED Equation.DSMT4}$$

This formula is derived as follows. The milliliters of plasma cleared per minute (C) times the mg/dL of plasma creatinine (P) must equal the mg/dL of urine creatinine (U) times the urine volume in in the urine. Therefore:

APPENDIX A

Urine and Body Fluid Analysis Automation

Urinalysis Automation

Studies have shown that the major variable in urinalysis testing is the conscientiousness of the laboratory personnel in their timing and interpretations of the color reactions.

Semi-Automated Urine Chemistry Analyzers

Semi-automated urine analyzers test for the chemical components of urine. The instruments read and interpret the reagent strip results consistently, thereby standardizing the interpretation of reagent strip results.

Positive results are flagged to indicate a patient sample that requires additional confirmation testing or microscopic evaluation.

The semi-automated instrument requires the operator to:

1. Dip the reagent strip into a well-mixed urine sample.
2. Blot the strip to remove excess urine.
3. Place the strip onto the reagent strip platform.
4. Press the analyze/enter button.

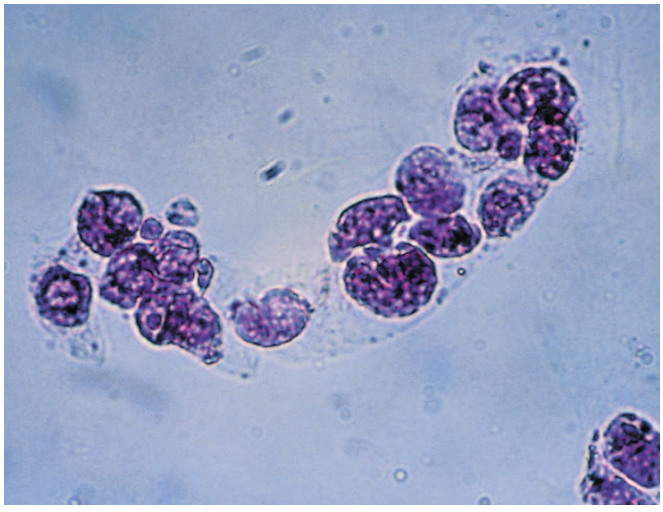

Figure A-1 DiaScreen50 semi-automated urine chemistry analyzer. (Image courtesy of U. S. ARKRAY.)

Sysmex UF-1000i

The Sysmex UF-*1000i* (Sysmex Corporation, Kobe, Japan) uses laser-based flow cytometry that measures forward light scatter, side scatter, fluorescence staining characteristics, and adaptive cluster analysis to identify stained urine sediment particles (Figure A-11).

Positive results are flagged to indicate a patient sample that requires additional confirmation testing or microscopic evaluation.

SUMMARY 3-4 Urine Casts

Hyaline

Appearance:	Colorless, homogenous matrix
Sources of error:	Mucus, fibers, hair, increased lighting
Reporting:	Average number per lpf Complete urinalysis correlations: Protein Blood (exercise) Color (exercise)
Clinical significance:	Glomerulonephritis Pyelonephritis Chronic renal disease Congestive heart failure Stress and exercise

RBC

Appearance:	Orange-red color, cast matrix containing RBCs
Sources of error:	RBC clumps
Reporting:	Average number per lpf
Complete urinalysis correlations:	RBCs Blood Protein
Clinical significance:	Glomerulonephritis Strenuous exercise

Positive results are flagged to indicate a patient sample that requires additional confirmation testing or microscopic evaluation.Positive results are flagged to indicate a patient sample that requires additional confirmation testing or microscopic evaluation.

$$\text{WBC/cmm} = \frac{\text{average number of cells} \times \text{dilution factor} \times 10}{\text{9 squares}}$$

Semi-automated urine analyzers test for the chemical components of urine. The instruments read and interpret the reagent strip results consistently, thereby standardizing the interpretation of reagent strip results.

Positive results are flagged to indicate a patient sample that

PROCEDURE A-1

Methylene Blue Stain for Fecal Leukocytes

1. Place mucus or a drop of liquid stool on a slide.
2. Add two drops of Löffler methylene blue.
3. Mix with a wooden applicator stick.
4. Allow to stand 2–3 minutes..
5. Place mucus or a drop of liquid stool on a slide.
6. Add two drops of Löffler methylene blue.
7. Mix with a wooden applicator stick.
8. Allow to stand 2–3 minutes.

requires additional confirmation testing or microscopic evaluation.

Semi-automated urine analyzers test for the chemical components of urine. The instruments read and interpret the reagent strip results consistently, thereby standardizing the interpretation of reagent strip results.

Positive results are flagged to indicate a patient sample that requires additional confirmation testing or microscopic evaluation.

Semi-automated urine analyzers test for the chemical components of urine. The instruments read and interpret the reagent strip results consistently, thereby standardizing the interpretation of reagent strip results.

Table A-1 Measurement Technology Methods in Automated Urinalysis

Urine Measurement Technology	
Color	Specific Gravity
ARKRAY, Inc	photometry
light scatter	refractive index
Iris Diagnostics	light transmission/light scatter
light transmission/light scatterrefractive index	Roche Diagnostics

References

1. Laboratory Production Solutions, Iris Diagnostics, August 31, 2012.
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3. Block, DR and Lieske, JC: Automated Urinalysis in the Clinical Lab. Medical Laboratory Observer (MLO), Vol. 44, No. 10, October 2012.
4. Block, DR and Lieske, JC: Automated Urinalysis in the Clinical Lab. Medical Laboratory Observer (MLO), Vol. 44, No. 10, October 2012.

Additional Information Sources

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Roche Diagnostics, Indianapolis, IN: HYPERLINK "http://www.roche.com" www.roche.com/products
Siemens Healthcare Diagnostics Inc. Deerfield, IL: http://www.usa.siemens.com/diagnostics
Sysmex America, Inc. Mundelein, IL: www.sysmex.com/usa